”Old Age” verses “New Age” in the Sustainment of Legacy Hardware

or

LEGACY DMSMS

An Archeological Adventure!

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
AUG 2011		**00-00-2011 to 00-00-2011**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
'Old Age' verses 'New Age' in the Sustainment of Legacy Hardware or LEGACY DMSMS An Archeological Adventure!	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Global Logistics Support Center (AFGLSC),409 SCMS/GUEA,460 Richard Ray Blvd, Suite 200,Robins AFB,GA,31069**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented to: DMSMS and Standardization Conference, Hollywood, FL August 29- Sept 1, 2011

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**31**	

Overview

- Current CAD-centric System Design
- Design Philosophy – BC (Before CAD)
  - System Performance is the Design Driver
    - High MICAP Rates
    - High CND and RTOK rates
    - High spares buy to facilitate “swaptronics”
    - Large BIT Ambiguity Groups
  - USAF Illustrated Parts Breakdown
  - DLA/FLIS Cataloging
- Capturing Design In A Pre-CAD World
- The Wild, Wild West of Part Usage

Contrast of Current and Legacy System Design Philosophies

Current Computer Aided Design -(CAD)

- Design rules integrated into the tool
- Disciplined Part Selection
- Balanced Design
- High Reliability
- Accurate Fault Detection /Isolation
- Designs Facilitate Sustainment
- Maximizes the use of Standard Parts

System Design – BC (Before CAD)

- Design rules just beginning to be understood
- Static OEM Preferred Parts List
- Unbalanced Design
- High CND and RTOK rates
- Poor Fault Detection
- Large Ambiguity Groups
- Low MTBF
- Designs Mandate Huge Spares Quantities (swaptronics)
- Maximized the use of NON Standard parts documentation.

Design Philosophy - CAD

- CAD incorporates all of the historical lessons learned into the design rules of the CAD software.
- Insures that the proper System Engineering process is utilized (no cheating).
- Insures accountable design margins are included in the CAD software.
- Results in a balanced design

Design Philosophy – BC

- Most of the Avionics Suite flown on the F-15 aircraft was designed in the late 1960's and very early 70's
  - System Performance was the design driver to the detriment of cost, schedule and sustainment.
  - No Computer Aided Design tools.
  - Slide Rules and Brain Power.
  - Prototype Brassboarding was essential to the design process.

Avionic Hardware Design - BC

- Design Engineers restricted to the OEM's Preferred Parts List (PPL) to implement their design.
- Preferred Parts List was never reviewed for DMSMS. If it occurred, it was fixed no matter the impact to keep the production lines running.
- Government restriction that no more than three percent (3%) of the OEM design data package could represent NON-STANDARD Part Types
  - ***OEM's were very cleaver in working around that restriction.***

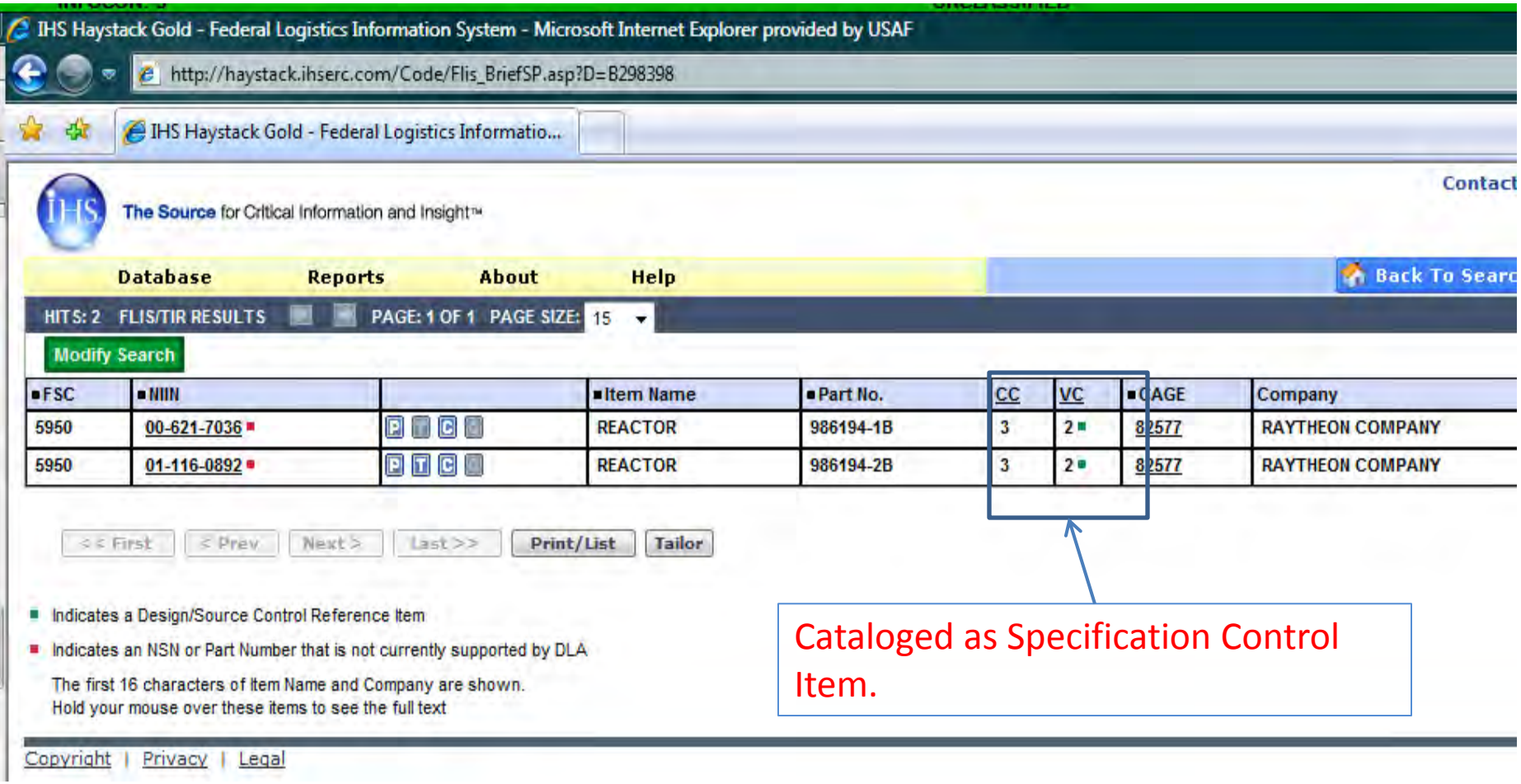
Capturing Design In A BC World

EXAMPLES OF CLEVER DESIGN DOCUMENTATION
WHILE MEETING SYSTEM NEEDS

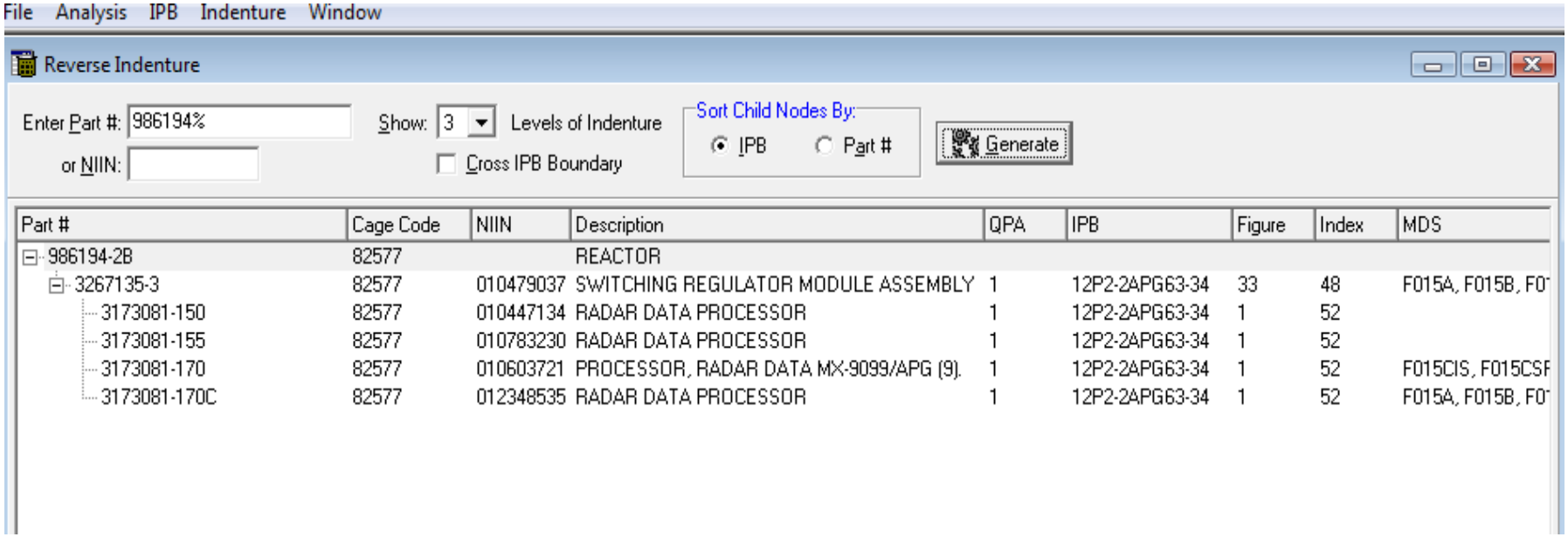
986194

These non-standard parts MUST be correctly cataloged or they are vulnerable to DLA/DSCC Item Reduction or Standardization actions with no input from System Engineering community. This is "obsolescence by cataloging"!

986194-1B Cataloging



986194 Depot Impact



Part #	Cage Code	NIIN	Description	QPA	IPB	Figure	Index	MDS
986194-2B	82577		REACTOR					
3267135-3	82577	010479037	SWITCHING REGULATOR MODULE ASSEMBLY	1	12P2-2APG63-34	33	48	F015A, F015B, F0
3173081-150	82577	010447134	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	52	
3173081-155	82577	010783230	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	52	
3173081-170	82577	010603721	PROCESSOR, RADAR DATA MX-9099/APG (9).	1	12P2-2APG63-34	1	52	F015CIS, F015CSF
3173081-170C	82577	012348535	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	52	F015A, F015B, F0

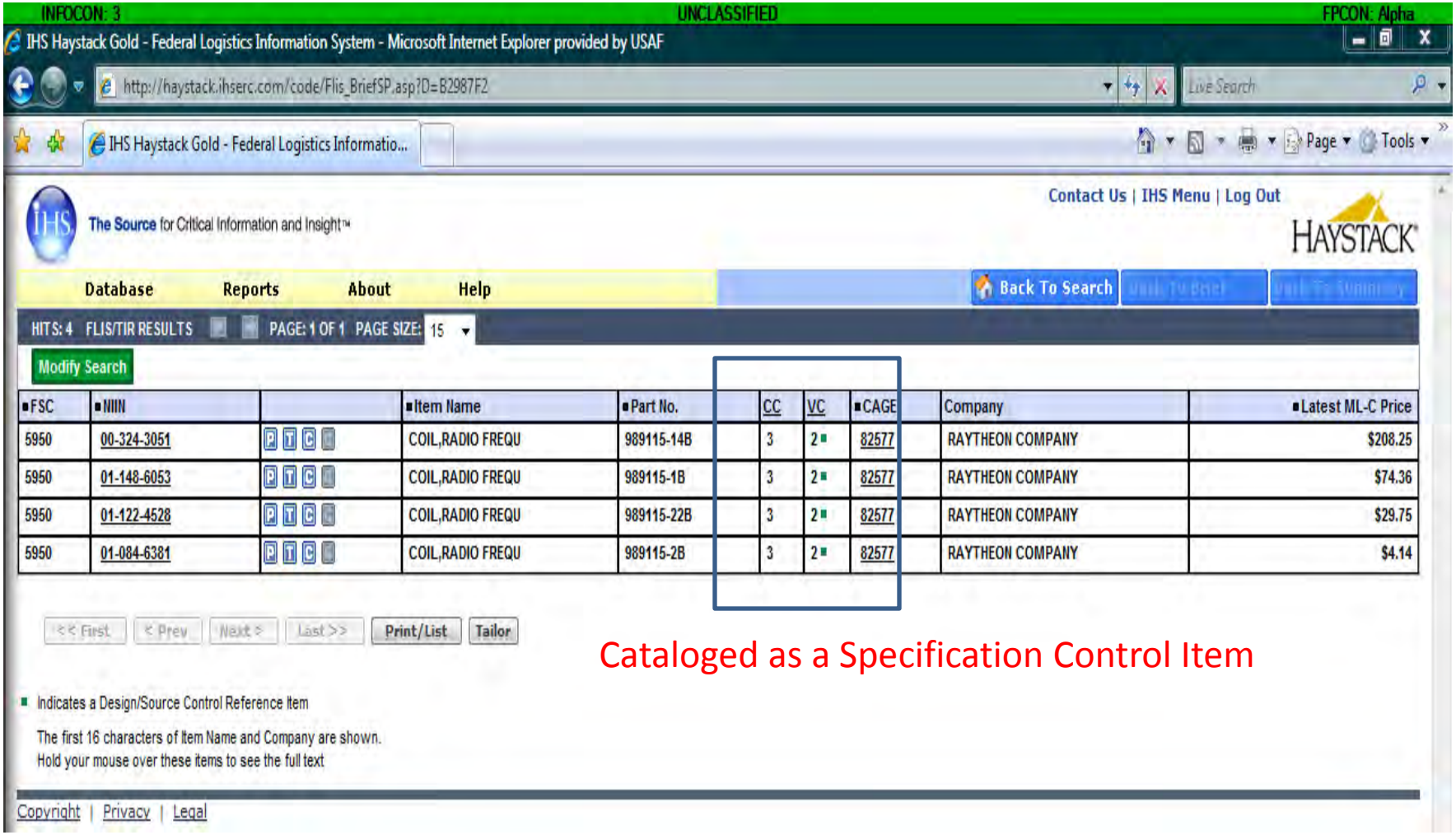
AN/APG-63 RADAR! This is a Mission Critical/Safety of Flight Application!

989115 Part Type

989115

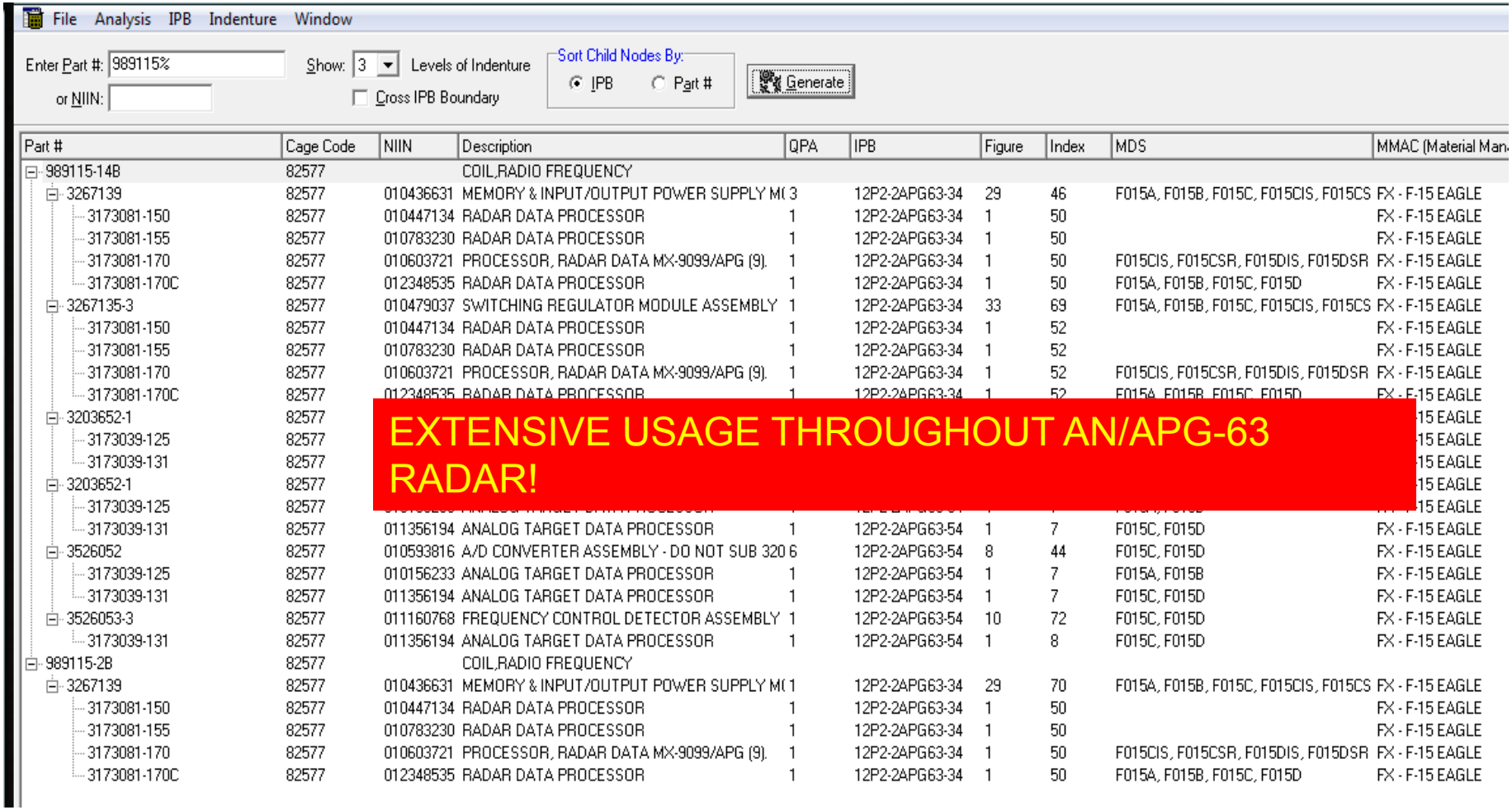
How is 989115 cataloged?

989115 Cataloging



Cataloged as a Specification Control Item

989115 Depot Usage



Part #	Cage Code	NIIN	Description	QPA	IPB	Figure	Index	MDS	MMAC (Material Man
989115-14B	82577		COIL,RADIO FREQUENCY						
3267139	82577	010436631	MEMORY & INPUT/OUTPUT POWER SUPPLY M(	3	12P2-2APG63-34	29	46	F015A, F015B, F015C, F015CIS, F015CS	FX - F-15 EAGLE
3173081-150	82577	010447134	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	50		FX - F-15 EAGLE
3173081-155	82577	010783230	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	50		FX - F-15 EAGLE
3173081-170	82577	010603721	PROCESSOR, RADAR DATA MX-9099/APG (9).	1	12P2-2APG63-34	1	50	F015CIS, F015CSR, F015DIS, F015DSR	FX - F-15 EAGLE
3173081-170C	82577	012348535	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	50	F015A, F015B, F015C, F015D	FX - F-15 EAGLE
3267135-3	82577	010479037	SWITCHING REGULATOR MODULE ASSEMBLY	1	12P2-2APG63-34	33	69	F015A, F015B, F015C, F015CIS, F015CS	FX - F-15 EAGLE
3173081-150	82577	010447134	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	52		FX - F-15 EAGLE
3173081-155	82577	010783230	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	52		FX - F-15 EAGLE
3173081-170	82577	010603721	PROCESSOR, RADAR DATA MX-9099/APG (9).	1	12P2-2APG63-34	1	52	F015CIS, F015CSR, F015DIS, F015DSR	FX - F-15 EAGLE
3173081-170C	82577	012348535	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	52	F015A, F015B, F015C, F015D	FX - F-15 EAGLE
3203652-1	82577								15 EAGLE
3173039-125	82577								15 EAGLE
3173039-131	82577								15 EAGLE
3203652-1	82577								15 EAGLE
3173039-125	82577								15 EAGLE
3173039-131	82577	011356194	ANALOG TARGET DATA PROCESSOR	1	12P2-2APG63-54	1	7	F015C, F015D	FX - F-15 EAGLE
3526052	82577	010593816	A/D CONVERTER ASSEMBLY - DO NOT SUB 320	6	12P2-2APG63-54	8	44	F015C, F015D	FX - F-15 EAGLE
3173039-125	82577	010156233	ANALOG TARGET DATA PROCESSOR	1	12P2-2APG63-54	1	7	F015A, F015B	FX - F-15 EAGLE
3173039-131	82577	011356194	ANALOG TARGET DATA PROCESSOR	1	12P2-2APG63-54	1	7	F015C, F015D	FX - F-15 EAGLE
3526053-3	82577	011160768	FREQUENCY CONTROL DETECTOR ASSEMBLY	1	12P2-2APG63-54	10	72	F015C, F015D	FX - F-15 EAGLE
3173039-131	82577	011356194	ANALOG TARGET DATA PROCESSOR	1	12P2-2APG63-54	1	8	F015C, F015D	FX - F-15 EAGLE
989115-2B	82577		COIL,RADIO FREQUENCY						
3267139	82577	010436631	MEMORY & INPUT/OUTPUT POWER SUPPLY M(	1	12P2-2APG63-34	29	70	F015A, F015B, F015C, F015CIS, F015CS	FX - F-15 EAGLE
3173081-150	82577	010447134	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	50		FX - F-15 EAGLE
3173081-155	82577	010783230	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	50		FX - F-15 EAGLE
3173081-170	82577	010603721	PROCESSOR, RADAR DATA MX-9099/APG (9).	1	12P2-2APG63-34	1	50	F015CIS, F015CSR, F015DIS, F015DSR	FX - F-15 EAGLE
3173081-170C	82577	012348535	RADAR DATA PROCESSOR	1	12P2-2APG63-34	1	50	F015A, F015B, F015C, F015D	FX - F-15 EAGLE

EXTENSIVE USAGE THROUGHOUT AN/APG-63 RADAR!

989141 Part Type

989141

This part is not stock listed but shows Depot Usage?!

Depot Usage

989113-15B, -17B, -19B, -37B
Part Type, Cataloging and Depot Usage

989113-15B, -17B, -19B, -37B

989113 Depot Usage

925525-501B

925525

925525 Depot Usage

Avionic Hardware Design - BC

- Design was committed to hardware in the form of a “brass board”!
  - Samples of every vendor who manufactured the needed function (e.g. dual NAND gate) was procured and the system functionality was built on a brass board.
  - If the functionality met system specs after a particular vendor’s part was inserted into the brass board, then that vendor’s part number was added to the OEM Specification!

Radar Example of Performance Driven Design

- Selected Item Source Control Drawings, e.g. 932047 Hex Inverter
  - 932047-501—Std datasheets limits for T_{PD} = 22nsec
  - 932047-502—Selected T_{PD} = 17nsec
  - 932047-503—Selected T_{PD} = 15nsec

  2 nsec diff in 1969!!
- Clearly the intent was to have this inverter as fast as technology would allow, relative to the other logic ICs in the design.
- Speed incompatibility with other replacement parts will result in Next Higher assembly bench failure, or worse, a CND

USAF – Illustrated Parts Breakdown

NOT MEASUREMENT SENSITIVE

MIL-PRF-38807C (USAF)
29 November 1996
SUPERSEDING
MIL-PRF-38807B (USAF)
10 April 1991

- **PERFORMANCE SPECIFICATION**
- **TECHNICAL MANUALS - ILLUSTRATED PARTS BREAKDOWN**

- This specification is approved for use by the Department of the Air Force and is available for use by
- all Departments and Agencies of the Department of Defense.

USAF – Illustrated Parts Breakdown

- 3.5.12 Parts standardization. The following paragraph shall be included in the foreword chapter:

"Parts Standardization. Authority for use of a part number different than the part number listed in this IPB is established by the Department of Defense (DoD) Interchangeability and Substitution (I&S) Program. Refer to the DO43B Master Item Identification Base for Air Force I&S information. *The maintenance technician has final responsibility and authority for determining acceptability of substitute parts.*"

DLA Cataloging

- Production and Deployment of New Systems
  - Initial Provisioning
  - Bill of Material Cataloging

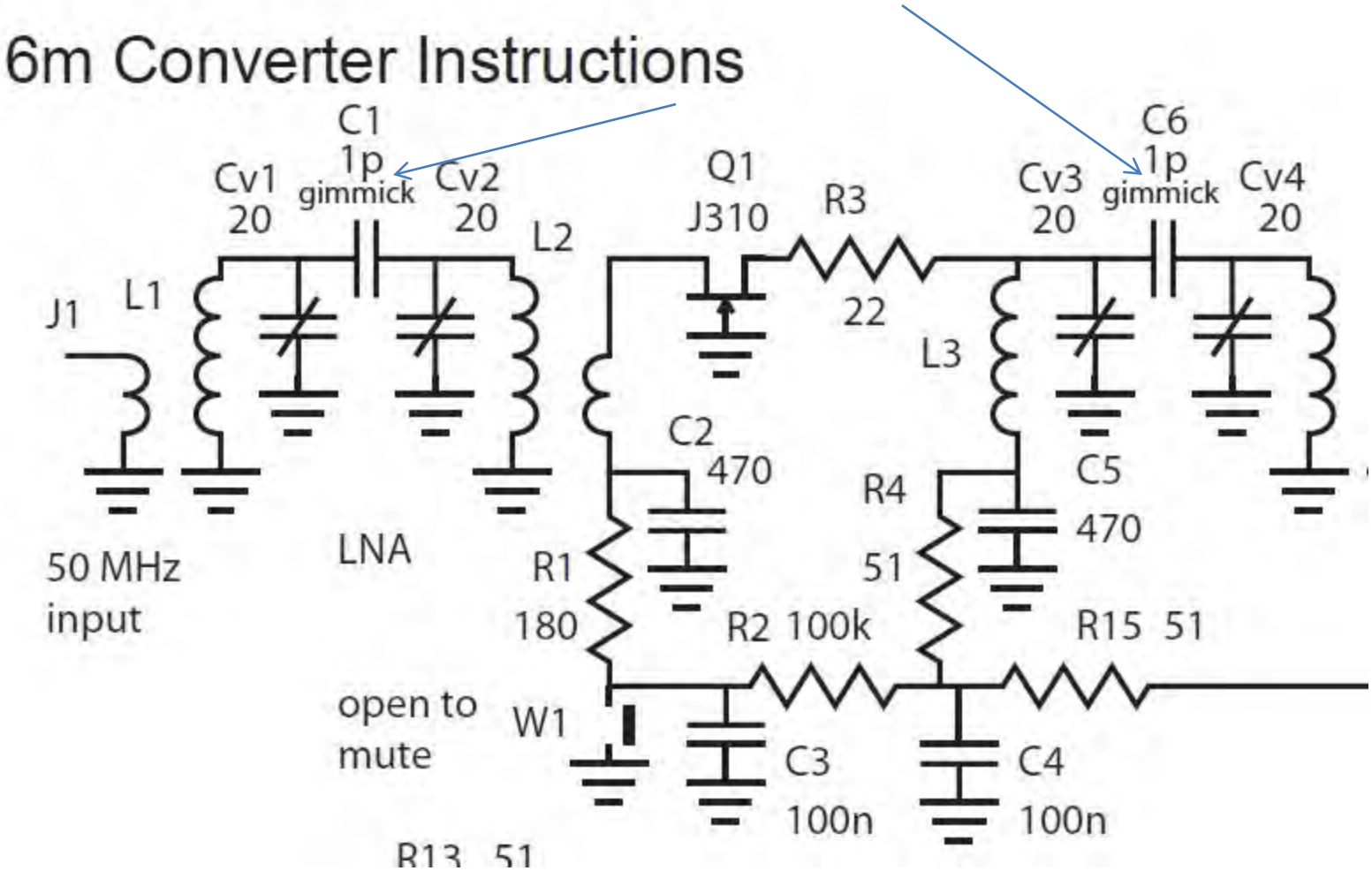
The Wild, Wild West of Part Usage

Triumph model 830 Oscillograph Wobbulator

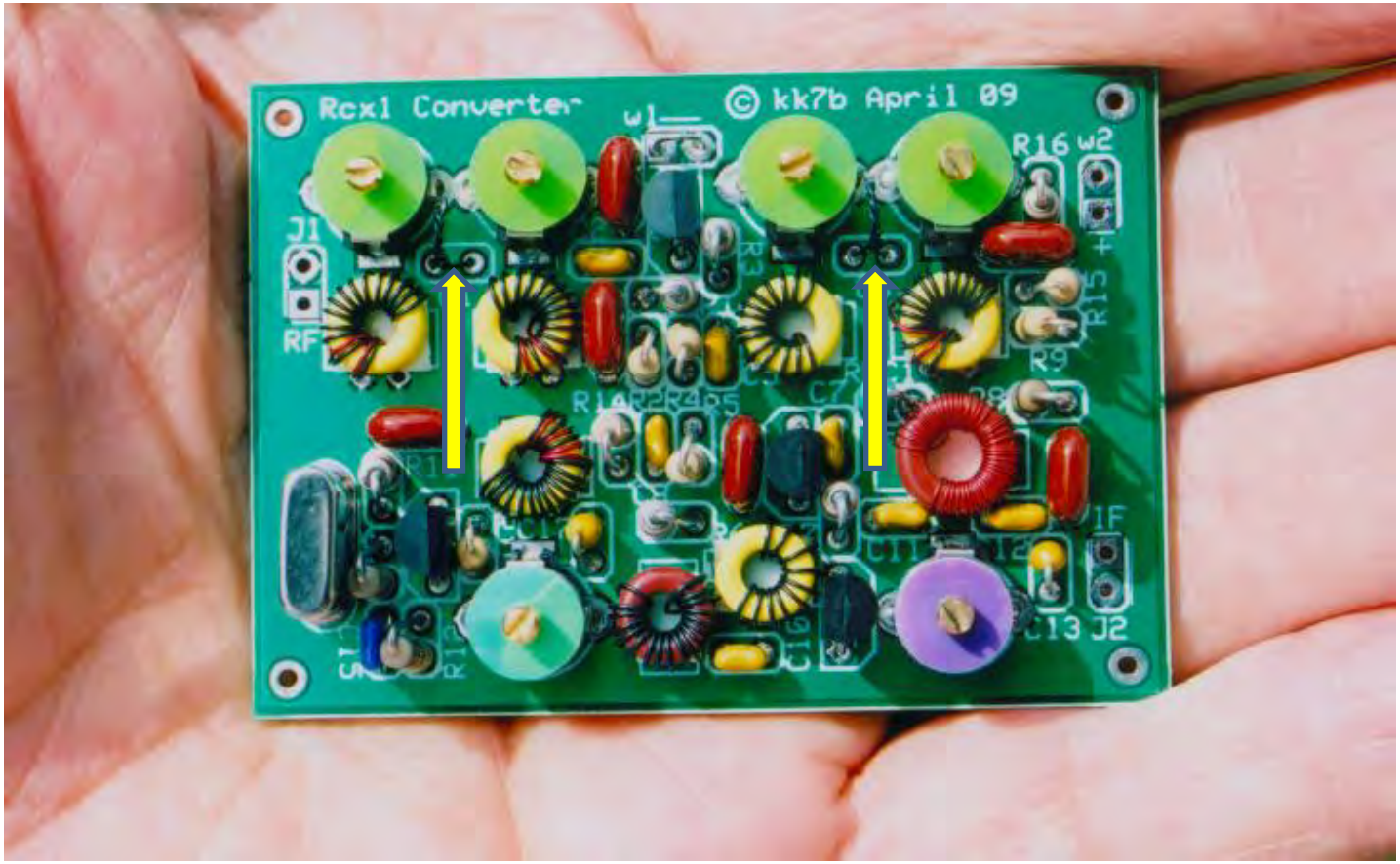
The Wild, Wild West of Part Usage

- System Design was Performance Driven
  - System Designers used parts in ways they were never designed to be used in order to meet performance requirement.
    - Electronic “gimmick”
    - Asynchronous Design
    - Flip Flop as a transient detector
    - Precisely cut wire as an inductor
    - Single ended performance requirement
  - Marginalized Reliability, Producibility and Sustainability

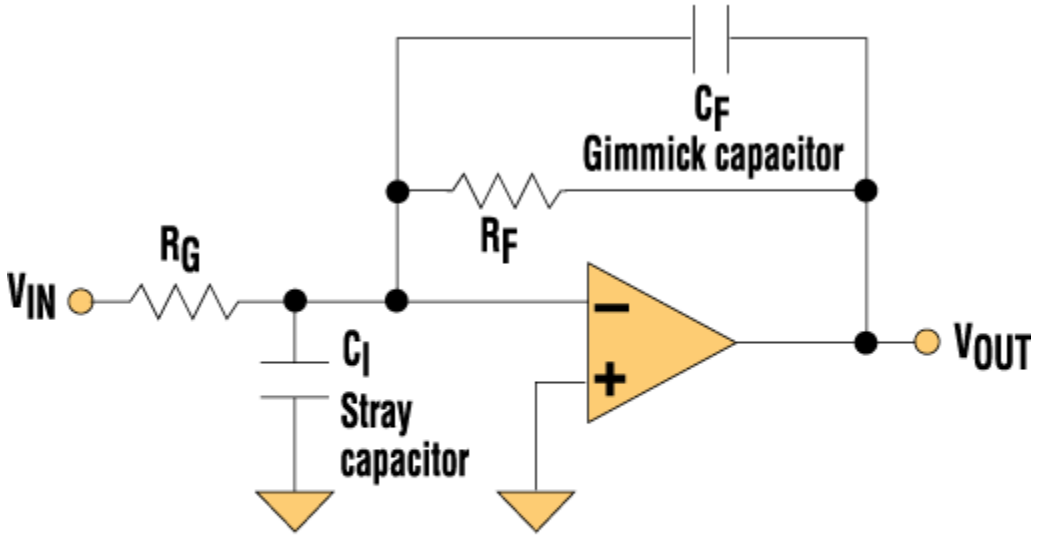
Gimmicks Captured in Schematic (in a 2009 design!)



Gimmick Capacitor



Gimmick Capacitor



1. To stabilize the op amp, the gimmick capacitor (CF) is made from copper traces and the circuit-board material.

SOFT FAILURES

Asynchronous Logic Design is the Major Culprit

Standard Design Methodology Pre-ASICS
Primary Cause for Soft Failures &
Can Not Duplicates—CNDs*

***A Soft Failure that only exists at environmental extremes**

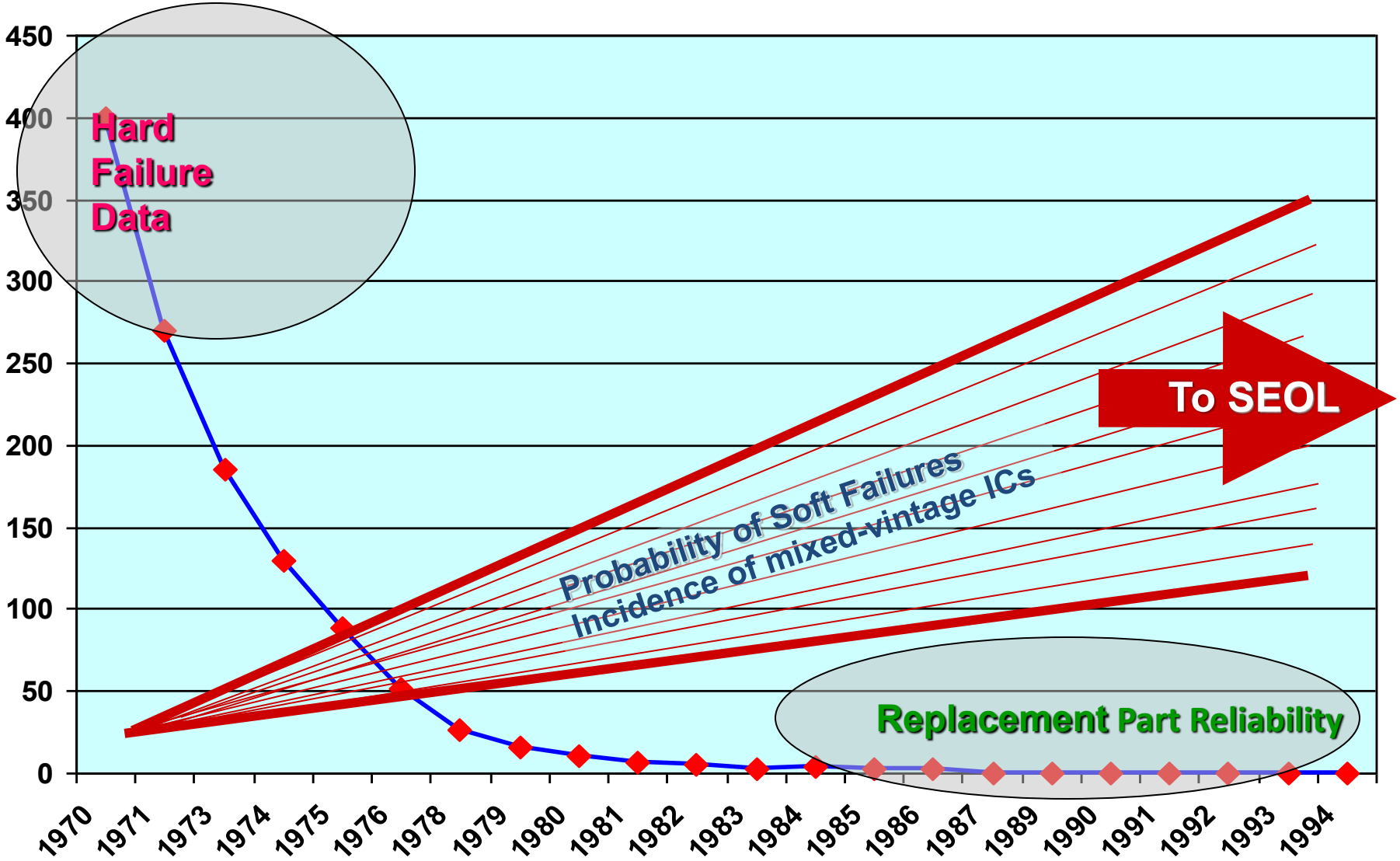
Potential Critical Malfunctions

All of the following conditions could be created with ICs that never go out of spec limits over the entire mil temp range

- The radar won't lock on to the target
- Countermeasures don't deploy
- Incorrect IFF transmit, or incorrect response
- Missiles won't arm
- Missiles won't fire
- etc.

This assumes that all use some digital asynchronous design in some portions of their design—highly probable

But—What's the Real Threat?



Speed Kills!

- Performance failures caused by speed of one IC relative to one or more others—*All within specification (including temperature)*
- If one IC is too fast relative to one or more other ICs, then the corollary is true, i.e. the other ICs are too slow for the first IC
- The predominant “bad” IC, called a failure, meets the procurement specification, it just doesn’t work in the NHA
- These “bad” logic ICs and their failures are occurring in use with other relatively new digital ICs
- Consider the magnitude this increases to when repairing a card populated with ’70s logic with 2010 ICs

[There is no identifiable direct analogy with analog circuits]

Summary

- These examples are just the tip of the Iceberg
- USAF System Engineers MUST insure that OSS&E requirements are met
- Cataloging is a part of the OSS&E process
- Legacy Designs are much more difficult to sustain than present balanced designs.
- The scary part is that none of this is being taught in the Engineering Schools of today.

Questions?